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Water Quality in Rock Creek and the West Fork of Rock Creek Red Lodge, Montana August 19, 1986

Mark A. Kerr

June 1987

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WATER QUALITY
IN
ROCK CREEK
AND THE
WEST FORK OF ROCK CREEK
RED LODGE, MONTANA

August 19, 1986

MARK A. KERR

State of Montana
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ABSTRACT

On August 19, 1986 a water quality survey of the Rock Creek drainage near Red Lodge, Montana was conducted to address concerns about the impact of development on Rock Creek and the West Fork of Rock Creek. Three stations were located on each stream upstream of their confluence and one site was located downstream of their confluence and the city of Red Lodge. Water quality parameters were selected to define the overall health of the streams and to assess the significance of suspected nutrient enrichment and organic pollution from areas of development. Periphyton samples were collected to assess the biological response to nutrient loadings.

The data indicated that organic and nutrient loads to both streams, associated with residential development along the corridors of Rock Creek and the West Fork of Rock Creek, were small. Impacts on water quality and periphytic community structure and composition were subtle and probably insignificant.

ACKNOWLEDGEMENTS

I would like to thank Dr. Loren Bahls of the State of Montana Water Quality Bureau for his work on the algal taxonomy and related environmental interpretations incorporated in this report. I would also like to acknowlege the work of Pamela Brewster in typing and editing this report.

1. INTRODUCTION

On August 19, 1986, a survey of Rock Creek and the West Fork of Rock Creek was conducted because of concerns about the impact of development in the two stream corridors on water quality. A reconnaissance survey was also desirable because of a scarcity of water quality data necessary to assess the overall health of the two streams.

Rock Creek and the West Fork of Rock Creek are characterized by intensive residential development for several miles upstream of the city of Red Lodge. Wastewater disposal practices are commonly considered one of the more serious threats associated with development to water quality. Other factors which may degrade water quality are erosion from areas of disturbed soil, the use of lawn and garden fertilizers, animal husbandry, and runoff from driveways and roads. As a reconnaissance survey, this study was not designed to determine specific sources of pollutants, but to determine whether either stream exhibited a decline in water quality which might be associated with some aspect or area of development.

2. OBJECTIVES

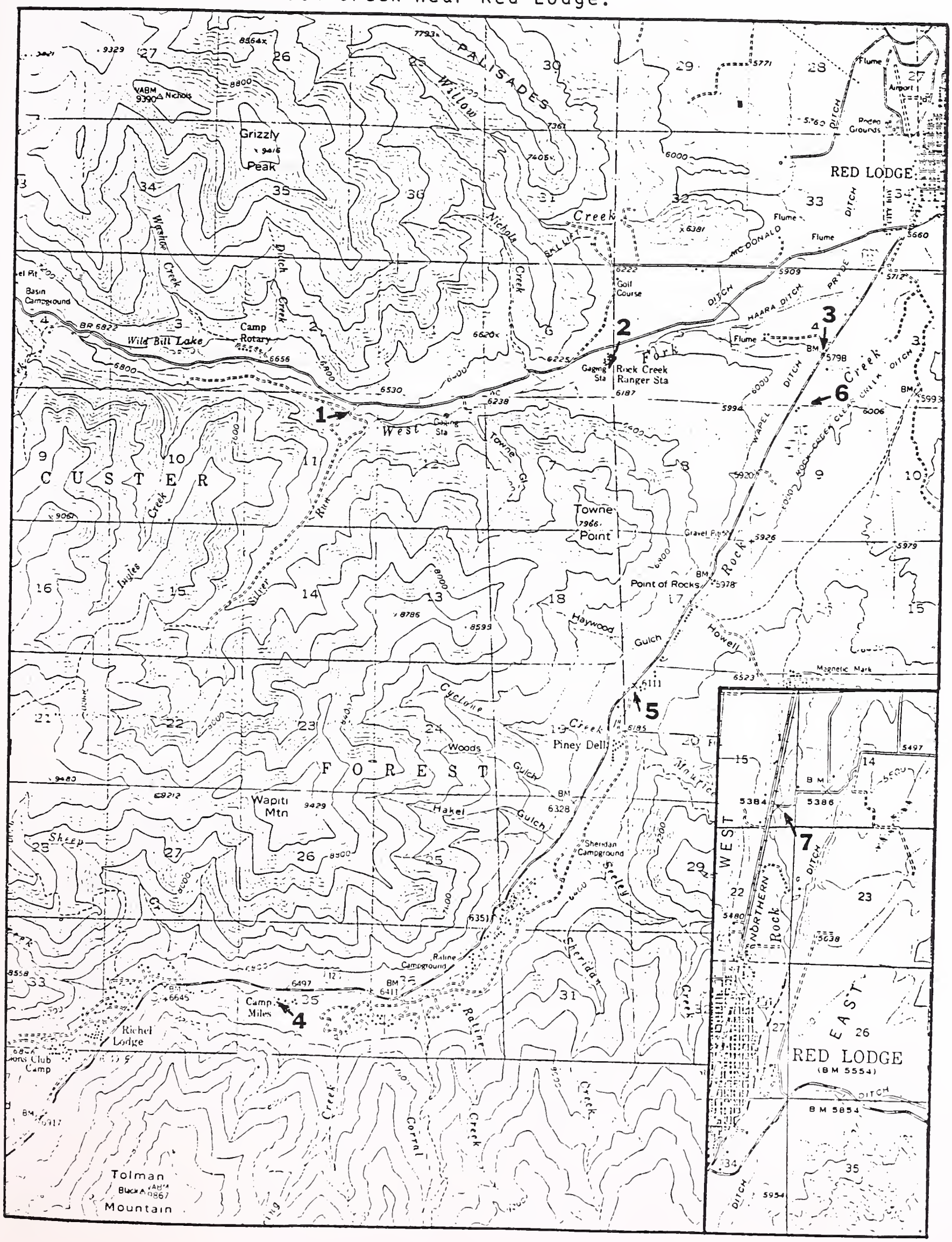
The objectives of this study were to assess the water quality of Rock Creek and the West Fork of Rock Creek and to determine whether development in the two stream corridors appeared to be degrading water quality.

3. STUDY DESIGN

The city of Red Lodge is located approximately one mile downstream of the confluence of Rock Creek and the West Fork of Rock Creek. Both stream corridors have been intensively developed for several miles upstream of the city. Further upstream, development has been less intensive.

Seven sampling sites were located on the two streams (Figure 1). Three sites were located on each stream above the confluence. Sites 1 and 4 were located furthest upstream on both

Figure 1. Location of sampling sites on Rock Creek and the West Fork of Rock Creek near Red Lodge.



creeks, in relatively pristine areas above most existing development, to serve as control sites. Sites 2 and 5 were located below areas of moderate development. Sites 3 and 6, immediately upstream of the confluence of the two streams, were located below areas of relatively dense development. Site 7, downstream of Red Lodge, was sampled to measure the change in water quality as Rock Creek flows through Red Lodge.

Sites 2 and 5 were especially important because some water quality data had been collected in 1976 and 1983 at these locations. These data would be useful for determining whether changes in water quality had occurred within the last ten years.

Water quality parameters were selected because they are good indicators of wastewater contamination (specific conductance, nitrate-nitrite, chloride, and fecal coliforms), or because they are useful in assessing the overall health of a stream and its ability to maintain a fishery (hardness, alkalinity, metals, and nutrients). Parameters were also selected so a comparison with the 1976 and 1983 data could be made. Periphyton samples were collected at five sites because they can provide an assessment of water quality conditions over time, which a one-time survey might not provide. Table 1 summarizes the parameter selection and location rationale for each sampling site.

4. METHODS

4.1 Field Sampling and Measurements

Water samples from all sites were instantaneous grab samples. Samples were preserved and shipped to the State of Montana Chemistry Laboratory in Helena for analysis. Samples for analysis of fecal coliforms were preserved and submitted to Energy Laboratories in Billings within the six-hour holding time limit.

Measurements of water temperature and pH were made at the sampling sites. Periphyton samples were preserved for analysis at a later date.

Table 1. Parameter selection and site location rationale for Rock Creek and the West Fork of Rock Creek.

SAMPLE SITE	PARAMETERS*	SITE AND PARAMETER SELECTION RATIONALE
1. W. Fork of Rock Creek above Silver Run	pH, conductivity, chloride, nutrients, fecal coliforms, periphyton	Upstream control site for W. Fork of Rock Creek, above most development
2. W. Fork of Rock Creek at Forest Service boundary	pH, conductivity, chloride, nitrate, orthophosphorous, fecal coliforms	Below moderate development; historical data available; indicators of wastewater contamination
3. W. Fork of Rock Creek above confluence with Rock Creek	pH, conductivity, chloride, nutrients, alkalinity, hardness, metals, fecal coliforms, periphyton	Lowest site on W. Fork, below intensive development; no historical data for metals; indicators of wastewater contamination and general water quality; comparison to upstream control site
4. Rock Creek below Lake Fork	pH, conductivity, chloride, nutrients, fecal coliforms, periphyton	Upstream control site for Rock Creek, above most development
5. Rock Creek at USGS gaging station	pH, conductivity, chloride, nitrate, orthophosphorous, fecal coliforms	Below moderate development; historical data available; indicators of wastewater contamination
6. Rock Creek above confluence with W. Fork of Rock Creek	pH, conductivity, chloride, nutrients, alkalinity, hardness, metals, fecal coliforms, periphyton	Lowest site on main branch above confluence, below intensive development; no historical data for metals; indicators of wastewater contamination and general water quality; comparison to upstream control site
7. Rock Creek below Red Lodge	pH, conductivity, chloride, nutrients, fecal coliforms, periphyton	Impacts of development and city of Red Lodge below confluence

* Nutrients include ammonia, nitrate and nitrite, total kjeldahl nitrogen, orthophsphorous, and total phosphorous.

4.2 Chemical Analysis

Physical properties of water which were analyzed include specific conductance, hardness, and alkalinity. Specific conductance was analyzed for all seven sites. Hardness and alkalinity, which define the susceptibility of an aquatic community to pollution from heavy metals, were analyzed only for the sites immediately above the confluence of Rock Creek and the West Fork of Rock Creek.

A nearly complete nutrient analysis was conducted. Total phosphorous, ammonia, and kjeldahl nitrogen were analyzed for all sites except sites 2 and 5. Ortho-phosphorous and nitrate-nitrite were analyzed for all sites, including sites 2 and 5. Data were collected in 1976 and 1983 for these parameters at these two sites. Fecal coliforms and chloride were analyzed for all sites because they are good indicators of sewage contamination.

Samples for the analysis of heavy metals were collected only from sites 3 and 6. Results are reported as total recoverable (TR) metals, which are metals solubilized by preservation of the sample to a pH less than 2.0. Metals included in the analysis were arsenic, cadmium, copper, manganese, iron, and zinc.

4.3 Periphyton Analysis

Periphyton samples from the natural substrate were collected at all sites except sites 2 and 5. The structure and composition of the periphytic community respond to organic loading and nutrient enrichment, and are therefore good indicators of water quality conditions preceding the sampling date.

Periphyton samples were analyzed for relative abundances of diatoms and soft-bodied algae. A shift in the abundance of one or several taxa, especially those known to be sensitive or tolerant to pollution, would be a response to nutrient or organic loading. Diatoms, a hard-bodied class of algae, were also analyzed for relative abundances of pollution tolerant and pollution sensitive species. Several key statistics for diatom

associations (total species, and the Shannon diversity index[1]) were calculated to determine the severity of nutrient and organic loadings to the two streams.

5. RESULTS

5.1 Water Chemistry

Water quality data for Rock Creek and the West Fork of Rock Creek are presented in Table 2. Except for iron, results of metals' analyses are not included. All metals except iron were at concentrations below the detection limit.[2]

Generally, the concentrations of most water quality parameters showed little or no downstream change. Water quality in the two streams appeared very similar at the control sites. In Rock Creek, no significant change occurred in any parameter above the confluence with the West Fork. Water quality in the West Fork, however, appears to decline slightly between the control site and the confluence. Specific conductance increased from 36 umhos to 74 umhos, and total phosphorous increased from .001 mg/l to .004 mg/l. The fecal coliform count increased from less than one colony per 100 ml. of water to 13 colonies per 100 ml. Water quality at the site below Red Lodge reflects the wedding of Rock Creek with the West Fork and the additional impact on the stream as it flows through Red Lodge.

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1 The Shannon diversity index, $\bar{d}$, is a measure which reduces the number of species in a sample and the distribution of individuals across those species to a single numerical value.

It is defined as $\bar{d} = -\sum_{i=1}^{S} (n_i/N) \log_2 (n_i/N)$

2 Detection limits for other metals which were analyzed are: arsenic (.001 mg/l), cadmium (.005 mg/l), copper (.01 mg/l) manganese (.005 mg/l) and zinc (.005 mg/l).

Table 2. Water quality data for Rock Creek and the West Fork of Rock Creek, August 19, 1986.

	W. Fork of Rock Creek above Silver Run	W. Fork of Rock Creek at USFS Boundary	W. Fork of Rock Creek above Rock Creek	Rock Creek below Lake Fork	Rock Creek at USGS gaging station	Rock Creek above W. Fork of Rock Creek	Rock Creek below Red Lodge
Field Temp. ^{0}C	9.5	9.9	10.7	9.8	9.9	10.2	11.2
Field pH	6.90	6.85	7.35	7.20	7.35	7.40	7.30
Total Hardness mg/l $CaCO_3$	--	--	32	--	--	15	--
Total Alkalinity mg/l $CaCO_3$	--	--	37	--	--	15	--
Specific Conductance umhos at $25^{0}C$	36	41	74	34	36	39	64
Ortho-P mg/l	<.001	<.001	.002	<.001	<.001	<.001	<.001
Total P mg/l	.001	--	.004	.001	--	.002	.002
NH_3-N mg/l	<.01	--	<.01	<.01	--	<.01	<.01
NO_2+NO_3-N mg/l	.06	.05	.04	.05	.05	.05	.07
KJLD-N mg/l	<.1	--	.1	.1	--	.1	.2
Fe (T.R.)* mg/l	--	--	.03	--	--	.01	--
Fecal Coliforms Col/100 ml.	<1	4	13	<1	3	2	14
Chloride mg/l	.2	.1	.1	.1	.1	.1	.1

* Total Recoverable

Tables 3, 4, and 5 present historical data collected in 1976 and 1983, and data collected in 1986. Data from 1986 were generally within the range of concentrations for the parameters analyzed in the earlier years. It cannot be concluded that any degradation of water quality has occurred in Rock Creek or the West Fork of Rock Creek in the last ten years.

5.2 Periphyton Analysis

The relative abundances of algal taxa, summarized in Table 6, indicate a small downstream increase in organic loading and/or nutrient enrichment in both Rock Creek and the West Fork of Rock Creek. The relative abundance of the pollution sensitive blue-green algae *Tolypothrix* and *Chamaesiphon* decreased downstream in the West Fork, and the relative abundance of *Nostoc* decreased downstream in Rock Creek. The relative abundances of the less sensitive green algae *Closterium*, *Zygnema* and *Ulothrix* increased downstream in both streams, while the relative abundance of *Staurastrum* increased downstream in the West Fork.

Data from the analysis of diatom associations are summarized in Table 7. One statistic, species diversity, indicates that there is some organic loading or nutrient enrichment of the West Fork. Species diversity, as measured by the Shannon diversity index, decreased at the downstream site in the West Fork. A decrease in the index often indicates a community under stress. Several species may be eliminated, or the abundance of several species may increase because of a competitive advantage. In Rock Creek, the change in species diversity between sites was inconsistent and appears to be insignificant.

The number of total species in a sample can also be a useful indicator of water quality. In Rock Creek and the West Fork, downstream changes in the number of species were too small to be meaningful.

Changes between sites in the relative abundance of certain diatom species indicated a slight downstream increase in organic loading and/or nutrient loading. The relative abundance of two pollution sensitive species, *Achnanthes minutissima* and *Hannaea arcus*, decreased downstream in Rock Creek and the West Fork,

Table 3. Water quality data for the West Fork of Rock Creek at Forest Service boundary, 1976 and 1986.

Date	Temp. °C	pH	Specific Conductance umhos at 25°C	NO_2+NO_3 N mg/l	Ortho P mg/l
5/25/76	3.0	7.80	43	.07	.013
6/07/76	4.0	7.30	30	.07	.001
6/21/76	7.0	7.40	33	.14	.003
7/06/76	6.0	7.20	25	.09	.011
7/19/76	6.0	6.90	25	.09	.003
8/03/76	6.5	7.30	30	.07	.003
8/16/76	6.0	7.20	40	.03	.018
8/31/76	6.0	7.50	45	.05	.011
8/19/86	9.9	6.85	41	.05	<.001

Table 4. Water quality data for the West Fork of Rock Creek above the confluence with Rock Creek, 1983 and 1986.

	4/19/83	8/19/86
Temp. ^{o}C	2.5	10.7
Total Hardness mg/l $CaCO_3$	27	32
Total Alkalinity mg/l $CaCO_3$	27	37
Specific Conductance umhos at $25^{o}C$	70	74
NH_3-N mg/l	<.01	<.01
NO_3+NO_2-N mg/l	.05	.04
Total P mg/l	.02	.004
Ortho-P mg/l	<.005	.002
Chloride mg/l	0.1	0.1

Table 5. Water quality data for Rock Creek at USGS gaging station, 1976 and 1986.

Date	Temp. °C	pH	Specific Conductance umhos at 25°C	$NO^2 + NO^3$ N mg/l	Ortho P mg/l
5/25/76	3.5	7.60	49	.09	.001
6/07/76	4.5	7.00	34	.07	.009
6/21/76	7.0	7.60	40	.13	.002
7/06/76	6.0	7.20	33	.08	.010
7/19/76	6.5	6.90	30	.09	.004
8/03/76	7.5	7.50	34	.08	.002
8/16/76	5.5	7.20	41	.05	.004
8/31/76	6.5	7.60	45	.07	.001
8/19/86	9.9	7.35	36	.05	<.001

Table 6. Relative abundance of diatoms and other algae in periphyton samples from the Rock Creek drainage near Red Lodge.*

	Station				
	(West Fork)			(Rock Creek)	
Algae	1	3	4	6	7
CHLOROPHYTA (green algae)					
Closterium sp.	R (6)	VC (3)	R	R (4)	C (6)
Mougeotia sp.					R
Scenedesmus sp.		R			
Spirogyra sp.			C (3)		C (5)
Staurastrum sp.		C (4)			
Ulothrix sp.	VC (2)	A (1)	C (4)	A (1)	C (3)
Zygnema sp.		R (5)			VC (2)
CHRYSOPHYTA (golden-brown algae)					
Bacillariophyceae (diatoms)	A (3)	A (2)	VC (2)	A (2)	A (1)
Hydrurus sp.				C (3)	R
RHODOPHYTA (red algae)					
Audouinella sp.		R	R	R (5)	
CYANOPHYTA (blue-green algae)					
Chamaesiphon sp.	C (5)				
Nostoc sp.			C (1)		
Phormidium sp.	C (4)	R		-	VC (4)
Tolypothrix sp.	A (1)	R	R		R

* Numbers in parentheses represent rank according to volume occupied by taxon in sample; R = rare, C = common, VC = very common, A = abundant.

Table 7. Key statistics for diatom associations in periphyton samples from the Rock Creek drainage near Red Lodge, August 19, 1986.

Statistic	Station (West Fork)		Station (Rock Creek)		
	1	3	4	5	7
TOTAL SPECIES	38	35	39	41	37
SPECIES COUNTED	30	30	30	34	32
FRUSTULES COUNTED	362	369	358	367	367
SPECIES DIVERSITY (Shannon)	3.27	2.97	2.88	3.17	3.00
PERCENT RELATIVE ABUNDANCE					
Achnanthes minutissima[a]	43.9	48.5	55.3	45.5	45.2
Cymbella minuta[b]	7.2	10.6	8.7	9.3	17.7
Fragilaria vaucheriae[b]	12.4	6.2	4.7	2.2	5.4
Gomphonema parvulum[c]	1.9	1.1	2.0	6.8	1.1
Hannaea arcus[a]	2.5	0.8	1.7	10.9	3.0
Synedra rumpens[b]	3.0	6.5	2.2	2.5	3.8
Synedra ulna[c]	0.0	6.2	0.0	0.0	7.1

[a] Species sensitive to organic pollution and nutrient enrichment

[b] Species more tolerant of organic pollution and nutrient enrichment

[c] Species most tolerant of organic pollution and nutrient enrichment

respectively. Several species more tolerant to pollution increased in relative abundance downstream. These were Cymbella minuta, Synedra rumpens, and Synedra ulna. However, the decrease in the relative abundance of pollution tolerant Fragilaria vaucheriae in the West Fork and the increase in the relative abundance of pollution sensitive Hannaea arcus in Rock Creek are inconsistent with a finding of organic and/or nutrient loading to the two streams.

6. DISCUSSION

The water quality data do not indicate that Rock Creek and the West Fork of Rock Creek exhibit any more than very minor, subtle effects from human impact. Above areas of development, the streams had very comparable, very high quality water. Nutrient concentrations were very low at all sites. All metals, except iron, were not detectable in samples collected at sites just above the confluence.

The West Fork is a somewhat harder stream than Rock Creek, although both would be classified as softwater streams. Fish and aquatic life in these streams could be particularly sensitive to even low concentrations of heavy metals, because heavy metals are more toxic in soft water than in hard water. It is unlikely that there is a major source of heavy metals in either watershed which would pose a threat to water quality and aquatic life.

The downstream increase in fecal coliforms in the West Fork is a good indication that there is some organic contamination of this stream. Fecal coliform contamination is addressed in State of Montana Surface Water Quality Standards. The West Fork of Rock Creek is classified as an A-1 stream above the city water intake and B-1 below. Streams in the A-1 classification must not exceed a standard of 50 coliform organisms per 100 milliliters of water. The coliform standard for B-1 classification is less stringent than the A-1 standard. The highest measured fecal coliform concentration was 14 colonies/100 ml. of water, which is far below the A-1 classification standard.

One problem associated with organic pollution is nutrient enrichment. Nitrogen and phosphorous compounds, in sufficient concentrations and under favorable conditions, can stimulate undesirable growths of algae. Streams which are relatively free from human impact generally have sufficient nitrogen but insufficient phosphorous for algae growth. Human impacts often include increased phosphorous input to streams, which overcomes the phosphorous deficit and results in nuisance growths of algae.

Nitrogen and phosphorous concentrations in both streams were at levels which should be considered typical of natural, undisturbed streams. At these levels, nuisance growths of algae would not likely be a problem. The Montana Department of Health and Environmental Sciences (DHES), on recommendation from the U.S. EPA Region VIII (DHES 1985), has adopted the following ambient nutrient concentration guidelines for assessing the potential for producing nuisance growths of attached algae in flowing waters:

1.0 mg/l total inorganic nitrogen
0.1 mg/l total phosphorous.

Total inorganic nitrogen (nitrate, nitrite and ammonia) in both streams was approximately .05 mg/l, and total phosphorous was less than .005 mg/l. Both are significantly less than the adopted guidelines.

The analysis of periphyton samples indicated that there was a small downstream increase in organic loading and/or nutrient enrichment in Rock Creek and the West Fork. However, the effects on periphytic community composition were subtle. Increases in the relative abundance of pollution tolerant taxa and decreases in the relative abundance of pollution sensitive taxa were small. Species diversity decreased slightly in the West Fork, indicating an aquatic system under a small amount of stress.

The West Fork just above the confluence was conspicuously different from all other sites sampled. Algae were very abundant, usually as a thin layer covering many rocks in the channel, but occasionally growing as dense, filamentous mats

around rocks in quiet areas in pools and near shore. The data did not show the nutrient profile here to be much different from other sites. The comparatively abundant algae growth does, however, indicate a difference from other sites.

One explanation is that the habitat here was very different from other sites, and more favorable for the growth of algae. Because of irrigation withdrawals and the city water intake, flow was reduced to an estimated five cubic feet per second (cfs) from an estimated 50 cfs above Silver Run. The decrease in flow, and downstream changes in gradient, decreased the stream's velocity and scouring ability. Water depth had also decreased, permitting greater light penetration to the substrate. Light penetration was also enhanced because the downstream reach was more open, with less forest cover, than the upstream reach. Decreased stream velocity and increased light are conditions which would favor the growth of algae, even at low nutrient concentrations.

A second explanation is that nutrient input to the West Fork is actually higher than the measured concentrations. Algae may have assimilated nitrogen and phosphorous rapidly, meaning that nutrients did not remain in the water column very long.

Even if undesirable algae growth was directly related to the input of nutrients, further work would be needed to determine the sources of nutrients if control measures were desirable. Possible sources include fertilizers, areas of soil disturbance, farm animals, and wastewater. A natural source, such as a high phosphate-bearing rock formation, could also contribute significant amounts of phosphorous to local streams and groundwater.

7. CONCLUSION

From this survey of Rock Creek and the West Fork of Rock Creek, it must be concluded that both streams are relatively pristine, and are affected in only the most subtle way by cultural development. Water quality data, fecal coliform analyses, and periphyton analyses indicate that organic loading and/or nutrient enrichment probably occur, not unexpectedly, in

association with residential development along both stream corridors. Water quality and changes in periphytic community composition data indicate that organic and nutrient loads to both streams were small. No attempts were made to identify the sources of these loads.

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